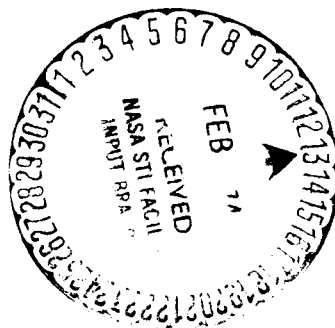




NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 9 MISSION
ANOMALY REPORT NO. 2

LANDING RADAR INTERFERENCE



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APOLLO 9 MISSION

LANDING RADAR INTERFERENCE

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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LANDING RADAR INTERFERENCE

STATEMENT

During the Apollo 9 mission, interference in the landing-radar sensing system began approximately 30 seconds after the descent engine reached full thrust and continued for the remainder of the 6-minute firing. These noise bursts occurred frequently during the initial period at full thrust but decreased in number as the firing progressed. Interference was also noted when the descent-engine thrust-chamber plug was discharged by initial thrust pressure.

DISCUSSION

The landing radar system in the Apollo 9 lunar module was modified to incorporate special outputs to the development flight instrumentation as a means of determining whether or not any interfering signals would be present during descent engine thrusting. Evaluation of flight data shows that interference was present on three of the four Doppler channels during the thrusting period. The fourth channel, used for altitude data, could not indicate interference, even if it were present, because of frequency response limitations. Interference is defined as a signal of sufficient strength and duration to cause lock up in any of the four Doppler frequency trackers in the landing radar electronics.

Figure 1 is a time history of throttle position, interference noise bursts, and Doppler tracker lock-ups. The frequent occurrence of noise bursts beginning at about 30 seconds after reaching full thrust caused three of the four Doppler trackers to lock up, as noted in the lower portion of the figure. The frequency of occurrence of these noise bursts decreased sharply after about 2 minutes, with a corresponding decrease in the number of lock-ups.

Analysis has shown the noise bursts were caused by flaking of the aluminized H-film installed on the base heat shield of the descent stage. The H-film, used to limit solar heating of the descent stage during trans-lunar coast, is taped to the base heat shield in an overlapping fashion. At temperatures above 800° F, the tape adhesive degrades and allows the sheets to flake off. A cross-section of the H-film installation and the actual temperatures experienced at four points are shown in figure 2. A photograph of the installed film is shown in figure 3. The flakes of H-film, as they break away and traverse the radar beams, act as small reflectors. Their relative motion therefore appears as a velocity to the landing radar and causes lock-up of the Doppler trackers.

Interference noise bursts were also noted during the period of initial thrusting from 10 to 40 percent which coincided with discharge of the descent engine thrust-chamber plug. This plug consisted of five sheets of aluminized H-film 0.5-mil thick and was installed (see fig. 3) to limit engine injector heat loss during translunar coast. As shown in figure 2, only one lock-up was experienced from the interference produced by the jettisoned plug.

CONCLUSIONS

Pieces of H-film from the base heat shield and the thrust-chamber plug for the descent engine acted as reflectors in the landing radar beams and caused interfering noise bursts in the velocity sensing electronics. Interference produced by the heat-shield H-film would be damaging to the performance of the landing radar during an actual descent to the lunar surface. Interference resulting from the jettisoned thrust-chamber plug is predictable and of very brief duration and therefore not considered a problem.

CORRECTIVE ACTION

A spray coating of KEL-F plastic was found to have acceptable surface and thermal characteristics at the temperatures involved, and this coating sublimates rather than flakes. Since this spray coating offers the same thermal protection to the base heat shield, it has been substituted for the H-film on Apollo 11 and subsequent missions. No corrective action involving the thrust-chamber plug is required.

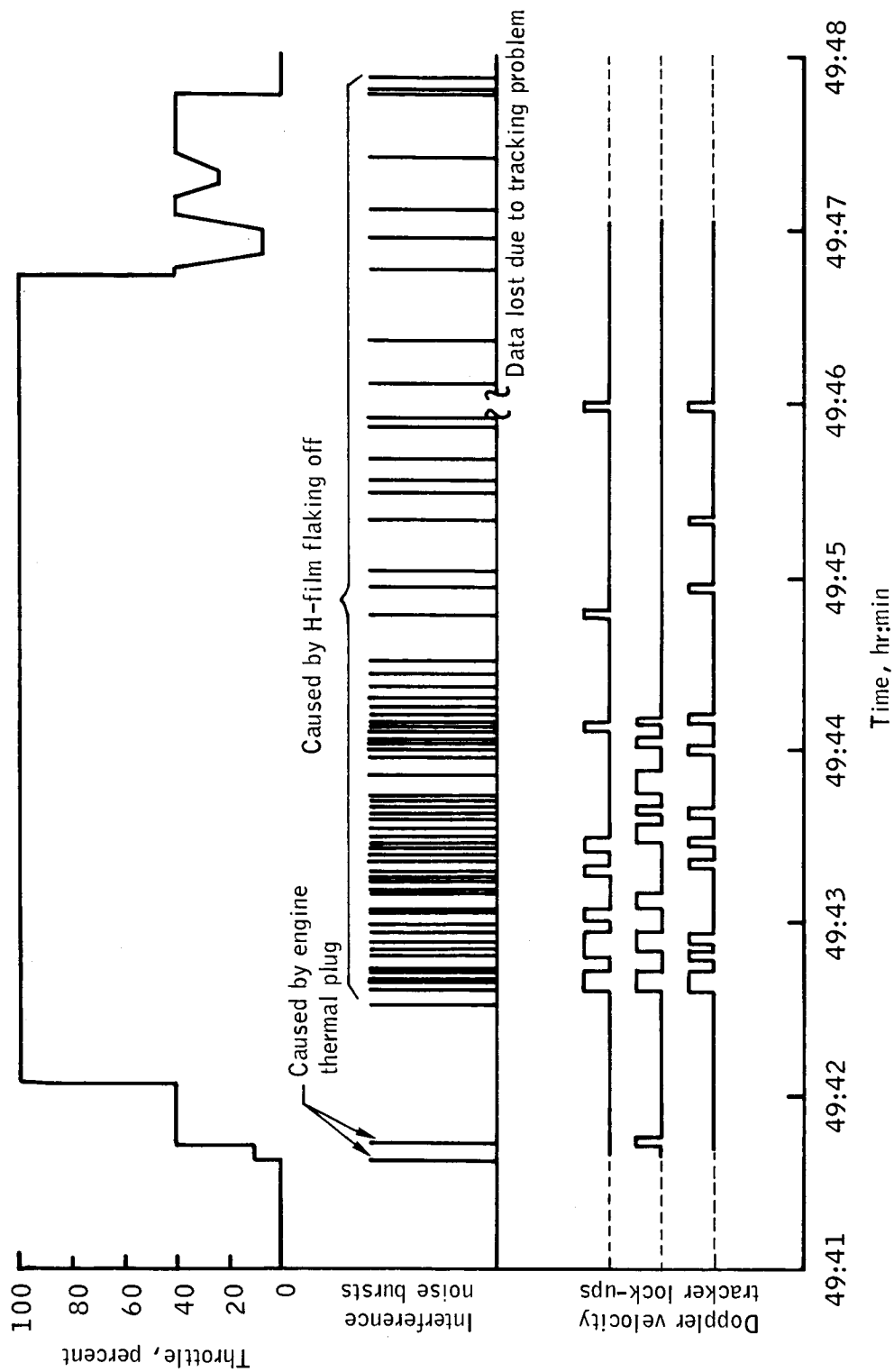


Figure 1.- Landing radar interference.

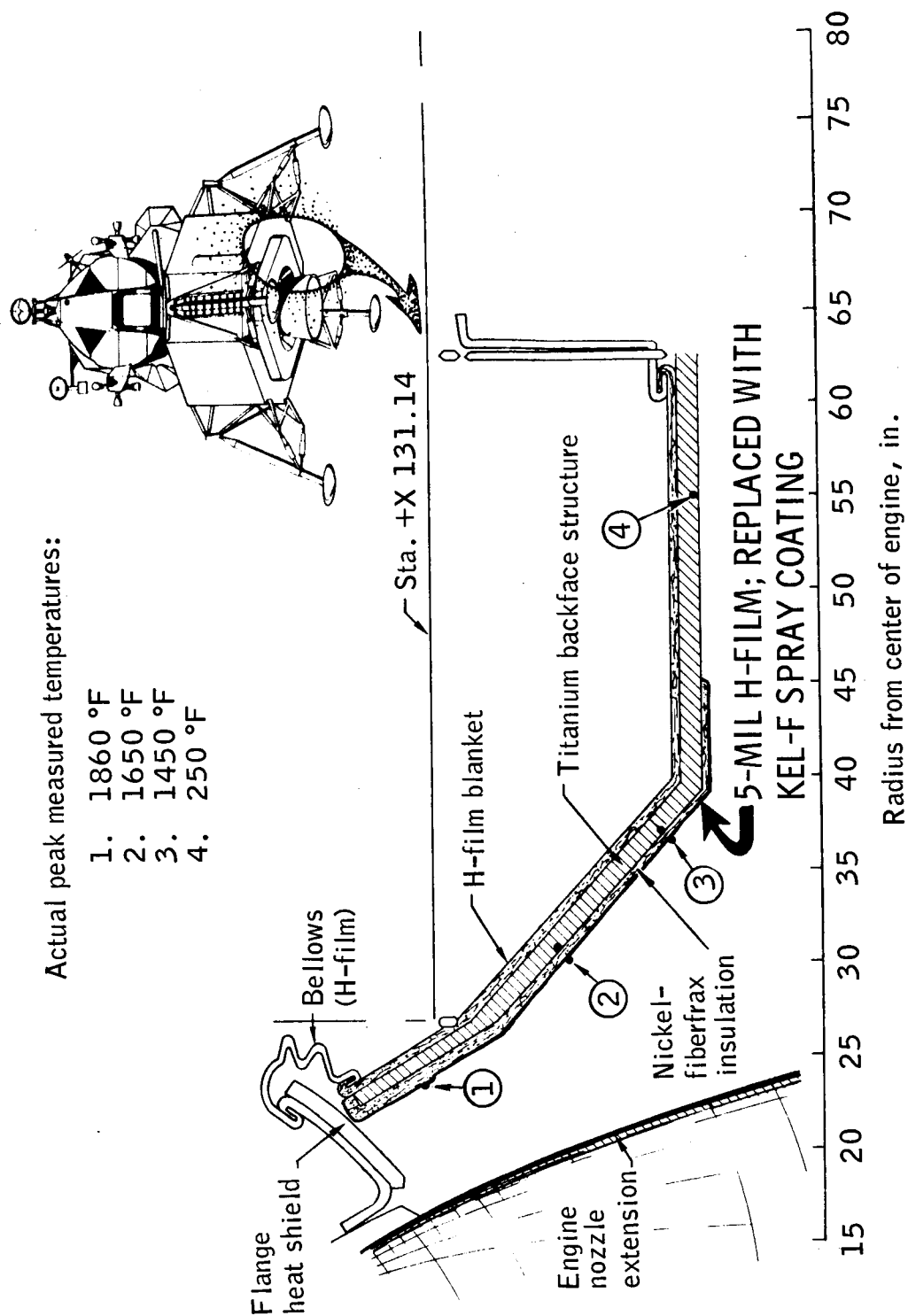


Figure 2.- H-film locations on descent stage base heat shield.

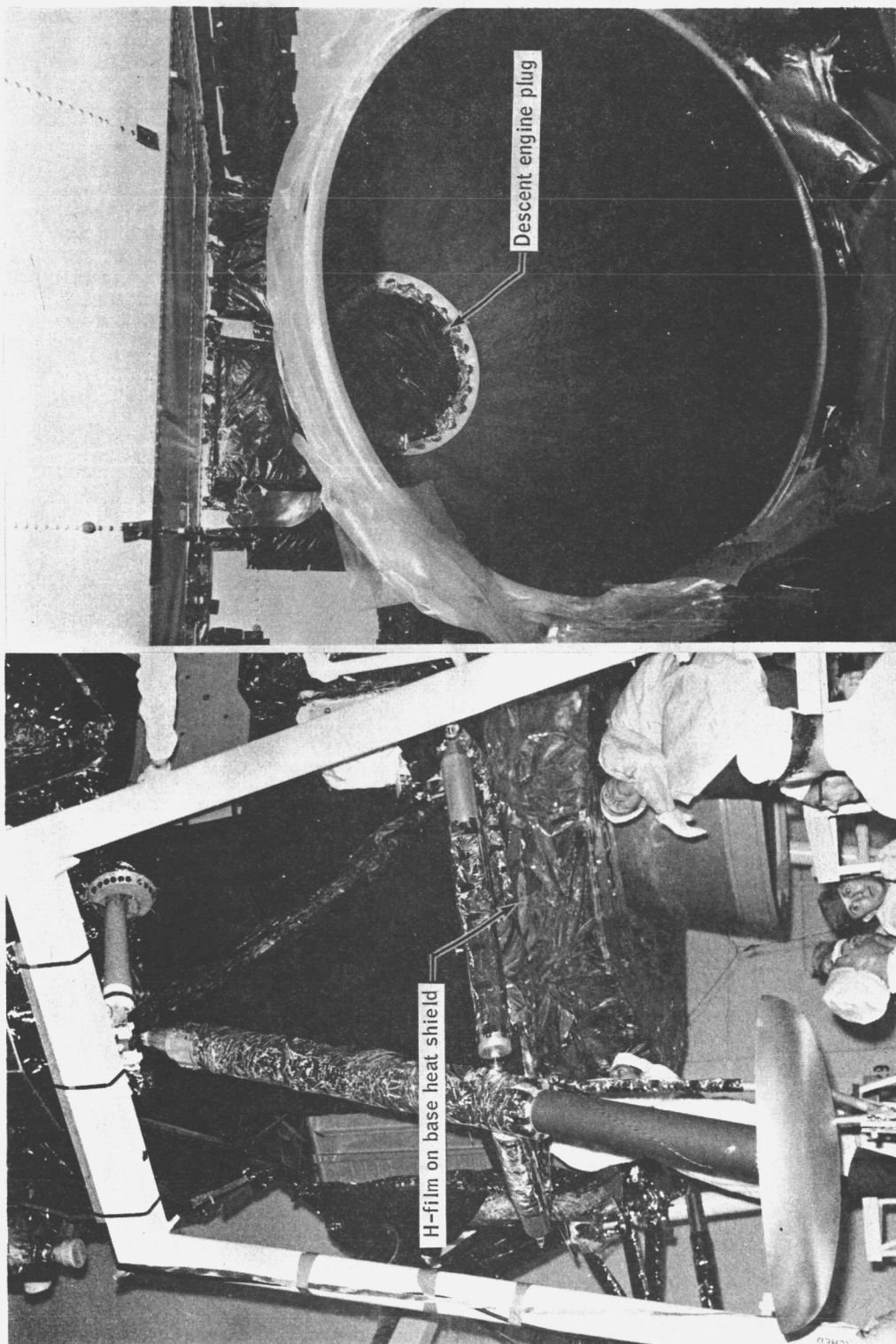


Figure 3.- H-film installations.